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Organization Research Program

THE M.I.T. ORGANIZATION RESEARCH PROGRAM: RESEARCH ON THE MANAGEMENT OF LARGE-SCALE TECHNOLOGY-BASED ENTERPRISES

Edward B. Roberts

September 1963 #34-63

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General Characteristics of the Program

In the spring of 1962 the M.I.T. School of Industrial Management, supported by a substantial grant from the National Aeronautics and Space Administration, undertook a major program of research and education related to the organization and management of large-scale, government-and/or-industry, research and development. Prior to this time most university research programs on R and D had been limited to narrow though important topics such as project selection, communication within laboratories, scientific creativity, etc. The usual scope of time, money, and faculty researchers in earlier investigations necessarily restricted the objectives of these programs. However, with the financial support of N.A.S.A. and the initial interest of a core group of faculty members, the M.I.T. program was conceived as a broadly-based long-term effort examining both government and industry R and D problems.

Now, almost eighteen months after establishment of the research group, the M.I.T. Organization Research Program has grown to involve about one dozen faculty researchers, aided by about twenty-five graduate-student research assistants, engaged in fifteen separately-identified but generally-related projects. At present the research is financed entirely by N.A.S.A. We shall, however, diversify our base of support beginning in January, 1964. The scope of the program is expected to remain approximately at its current level during the next several years.

Before describing the research work in progress, it seems appropriate to make some general comments about the style of our research. First, the general focus is on management questions relating to research and development activities. In the near future some efforts may broaden our scope to problems of technically-based organizations in general, in which our concerns will encompass the impli-

cations of R and D activities for other aspects of the organization as well. Within this general focus, individual faculty members propose and conduct investigations under the over-all guidance of an eight-man steering committee, chaired by Professor Donald G. Marquis, who is also research director of the Organization Research Program. Almost all of the faculty researchers are from the School of Industrial Management, yet their background disciplines include psychology, economics, management science, political science, sociology, and engineering. Some of the research work is basic while other work is more applications-oriented. Tangible results may not be found in some projects for another five years while other studies expect to recommend changes in policies or practice within the next year. It is important to stress that this research program views no single approach to research as either necessary or best. The principal investigators are using a mixture of research methods which include pure theory-building, controlled laboratory studies, computer simulation analyses and other mathematical modelling approaches, field surveys, and case studies. The taste and judgment of the faculty researcher, with possible guidance from the steering committee, determine the style of research used in any single study. Finally, our program includes research directed at all levels of R and D problems, from the individual researcher to the national economy. Each level of research interacts with at least the next level, especially in terms of evaluation criteria. The output of the individual scientist or engineer becomes part of the factors considered in studying technical groups; these in turn interact with laboratory or organization results, and so on.

Research in Progress

The various instituttional levels of research and development activity provide a natural outline for reviewing our research work in progress. Whether studying the individual engineer or the impact of R and D on society as a whole, the research studies can be characterized as having an almost universal concern with finding causes and measures of effectiveness. In several areas studies are continuing with full recognition that one output desired by the investigator is a set of criteria for evaluation of his own work. In classifying the projects into reference levels for this review, I shall place them according to the principal aspect of interest to the researcher. Surely many of the studies fall into several possible classes where their results will be equally applicable.

National Level

Two very different studies are in process which are examining questions relevant to the national economy or national policy-making institutions. In the first of these William H. Gruber is examining the implications of technological change for our gross national product. This is a subject of major controversy and of national importance. Already Mr. Gruber has discovered that recently-published results of research on this topic have drawn conclusions based largely on erroneous data. He hopes to develop some meaningful indicators that might help us measure the value of research to our nation.

Another study, conducted by Professor Robert C. Wood and his team of graduate researchers from our Political Science Section, is delving into the process of national policy-making relative to R and D. His first of a series of case studies examined the origins of N.A.S.A. and the writing of the "Space Act". The nature of this research on the interactions between the

Executive Office, Cabinet departments, Congress, and various special interest groups is extremely sensitive but can provide new insights into the political environment surrounding space agency policies. Case analyses are now being prepared about the Space Council, D.O.D. - N.A.S.A. liaison groups, N.A.S.A. facility location decisions, communication satellite policy, and others.

Government-Industry Interface: the Contracting System

From the time of receipt of our grant from N.A.S.A., I have been engaged in a three phase study aimed at designing a more effective system for government contracting. The first phase consists of a series of detailed case studies of R and D award decisions made by N.A.S.A. and Department of Defense contracting centers. The twenty-five decisions studied thusfar, using analyses of government record files and extensive interviews with technical and negotiating personnel, are leading to a better documented understanding of the real decision-making structure in the contracting process. Phase two of this research program consists of company analyses aimed at determining proposal strategies and their relative effectiveness. In these investigations we are also seeking company opinions on the bases of government contract awards. This will highlight gaps in communication between government and industry which may work to one and/or the other's disadvantage. During the final phase of the study, not yet underway, we will develop an integrative Industrial Dynamics model of the contracting process so that we can use computer simulation to experiment with the design of new policies.

Laboratory, Research Center, or R and D Organization

Several different studies are examining problems of management of the technical organization as an entity. The most extensive of these is a field study that is gathering detailed ten-year histories of fifty major R and D laboratories or organizations. This research, directed by Professor Donald

G. Marquis and Dr. Richard B. Maffei, is obtaining data on project performance, changes in personal competence, sales activities, etc., which will increase our knowledge of laboratory effectiveness. Histories have been gathered from a number of major organizations during the past few months and analyses will be undertaken within the present academic year.

A second field research study is intended to provide new understandings about the effects of physical design of an organization's work space upon the work done within that space. Under leadership of Professor Bernard J. Muller-Thym, communication patterns within several projects at one N.A.S.A. field center were studied, using interviews and specially-prepared personal communication logs. Data analyses completed on two of the projects reveal high correlation between frequency of contacts and the space between communicants. Further research in this area may lead to new concepts for physical organization design. The same research project is examining the communication patterns among people possessing various competences used in completing an R and D task. The changing dynamic character of these communications during a project life cycle may provide some new insights for monitoring project progress.

Professor James C. Emery is also working on a problem of relevance to an R and D organization as a whole. He is attempting to design a management information system that incorporates both planning and control activities. The system might, for example, use simulation models for studying alternate organization plans and heuristic programming techniques for adjusting decision parameters within the system. The results of this effort will obviously be applicable to non-R and D activities as well as to technology-based enterprises.

My work at this level has been devoted to the development of a general dynamic model of R and D organizations, stressing structural characteristics (including traditions and policies) which create growth and decline of overall

technical effectiveness. During the past year a model was constructed, derived in part from a study of the M.I.T. Instrumentation Laboratory. In the coming year I intend to further develop this model and to conduct simulation analyses of various policy changes by laboratory management.

Project Level

Two of our studies focus sharply on the problems of large-scale project management. The first of these involves extensive field research, led by Professor Marquis and Dr. Maffei, that is being conducted in parallel with their comparative study of R and D organizations. Data is being collected on completed projects (between $1 million and $20 million in size) conducted by industrial organizations under contract with a government agency. Records of cost, time, technical accomplishment, critical problems, management organization, personnel qualifications, and other aspects of project history are being assembled from company and government files and from interviews with the project manager and the technical monitors. Analysis will be directed at determining critical factors influencing project performance.

The second project level research effort is my attempt to develop a general theory that explains the dynamic behavior of R and D projects. This was initiated as part of my doctoral dissertation. An Industrial Dynamics model of the theory was created and studied through several hundred computer simulation experiments. The completed study, including conclusions on government and industry policy for project management, is reported in my forthcoming book, The Dynamics of Research and Development, which will be published later this year by Harper and Row. Current effort related to this general model is aimed at simplifying some important parts of the system model for use as a teaching device.

Research Groups

At the organizational level below the entire project, that of the research group, we also have two active studies. Professor William M. Evan is examining conflicts which arise in research groups, attempting to identify the form and extent of the conflicts and whether or not they are harmful or helpful to attainment of R and D performance. Professor Evan has now studied large groups of engineers and scientists in two government and two industrial organizations. Tentative conclusions from the data indicate that two basic types of conflict exist--task-related and interpersonal. Moreover, it seems that task conflict, that is, disagreements within groups arising over technical aspects of work, correlates with high technical performance, whereas interpersonal conflict correlates with low group performance. These studies are being extended and will be analyzed in further detail within the near future.

The second study at the research group level is being conducted by Professor Marquis and Thomas J. Allen. They are examining group problem-solving in the context of competitive proposal preparations and parallel R and D study contract efforts. These situations provide the rare opportunities in R and D in which a number of companies work on the same task and therefore can be compared. Results of the few proposal competitions evaluated thusfar suggest that the use of technical specialists within the company is a strong determinant of the technical quality of the proposals. Similarly the detailed data gathered so far indicate that the use of outside consultants has a consistent negative correlation with proposal quality. This research program will soon be extended to include larger samples and more complete information on the factors affecting the quality of problem-solutions.

Individual Researcher

The final, but perhaps basic, level of investigation within the M.I.T. Organization Research Program includes several studies of the individual scientist or engineer. One research project directed by Professor Edgar G. Schein is examining patterns of career development of N.A.S.A. scientists, engineers, and administrators. Over one hundred personnel have been interviewed in two N.A.S.A. field centers to uncover technical, managerial, institutional, and personal factors which contribute to individual growth and development. This study is now being extended using revisions suggested by the initial test groups. The ultimate end-product of such a study would be the design of organizational policies that would enhance the competence and contributions of researchers over their career span.

Professor Andrew C. Stedry is making a two-fold attack on the problems of effort allocation by individual engineers and engineering supervisors in response to the multiple goals felt by each person. Theoretical models are being further developed which attempt to represent rational behavior of goal-seeking individuals. These models then serve as a basis for comparison with data obtained from field research studies, undertaken thus far in the laboratory departments of a large electronics firm. Personal goals were found to have some effect on effort allocation. Incidentally, the participating company was surprised to find how large a percentage of the time of engineering managers was being devoted to actual technical work.

The last project to be listed is in reality a series of closely-related studies of individual problem-solving. Five faculty members, Professors Marquis, Stedry, Geoffrey P. E. Clarkson, William F. Pounds, and O. Peer Soelberg, are carrying out separate investigations of various aspects of individual problem-solving behavior, coordinated by frequent discussion meetings among the researchers. These studies are largely using subjects in controlled laboratory settings,

some of which are in effect simulated research-problem environments. Real-time and time-sharing computer systems have been employed successfully in the pilot studies, with other approaches planned for use during this coming year. This effort, in particular, is viewed as a long-term basic research exploration that might have significant potential to R and D management insights.

The many research projects in progress constitute a broad program covering the gamut of R and D management problems from a variety of viewpoints. The research results have already begun to accrue in what we anticipate will become an ever-increasing flow.

Other Program Accomplishments

In addition to the tentative findings indicated during my description of the individual research studies, other results of the Organization Research Program are also being produced.

Education in R and D Management

One of the goals of our efforts is the development of an organized program of education in the field of research and development management. Several signs of progress in this direction are now available. During the past academic year two weekly seminar programs were conducted under the leadership of Professor Marquis. One for graduate students was run in a lecture-discussion style, with a different faculty researcher each week presenting ideas on different aspects of R and D management. The second seminar was more research-oriented, and served as a means both for information exchange among members of the Organization Research Program and for learning from representatives of government, industry, and other universities of their activities. These two seminars will continue this year.

An increased flow of scholarly research publications is gradually being produced, providing both theory and data for education of students of management. These include almost twenty Master of Science theses written within the past nine months under supervision of faculty members of the Organization Research Program. Doctoral dissertations will soon be added to this literature, since we have recently added to the School's Ph.D. program the possibility of a major field in R and D management.

Strength for the Future

The major accomplishment of our program thusfar, in terms of potential long-term value, has been the establishment of a cadre of interested faculty, working together in cooperative research on problems of national importance. The payoff from several years of such interdisciplinary effort can be quite considerable and need not even relate to the current research outputs. The nature of such a university research center follows the best traditions of organizations like the Cowles Foundation in Economics at Yale, the Survey Research Center of the University of Michigan, and M.I.T.'s Center of International Studies. Furthermore, the future will also benefit from N.A.S.A.'s foresight in establishing at other universities research centers patterned in part after our Organization Research Program. These groups will focus on social, economic, and managerial problems related to the space effort. This movement will ensure a gradually increasing emphasis by our universities on these very vital non-technical aspects of technology development.

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